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# ON THE CORROSION RESISTANCE OF METALS IN FREON

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# ON THE CORROSION RESISTANCE OF METALS IN FREON

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ABSTRACT. The authors show that many metals and alloys are subject to corrosion in freon-11 when the temperature is raised to 300 degrees C and the pressure increased up to 60 atm. The most corrosion-resistant proved to be Kh17N2 steel. The 20, 45, U8, and 4Kh13 steels also proved to be sufficiently resistant. At the other extreme, copper and brass were found to be the least resistant. These metals turned into a shapeless mass after a short period of time. Also quite non-resistant were the VTZ-1 titanium alloys and VD-17 aluminum alloy.

The polyfluorochlorohydrocarbons, known also as freons, are used chiefly in the refrigeration industry as cooling agents. But the intense development of modern technology leads to the widening of the range of freon application. Owing to their good thermodynamic properties and a number of other positive features, freons have found wide application as heat carriers in turbocompressor, steaminjector, and also pumpless hermetic machinery [1]. Freons are also used as solvents and as intermediate products for the synthesis of fluorine derivatives. Due to their low boiling point freons, as a rule, are used at high pressures in a large temperature range. /178[1]

According to [2,3] freons (exceptionally stable compounds) do not hydrolyze and therefore are chemically inert in relation to metals. True, some authors [4,5], noting the considerable inertness of freons toward metals, point to the magnesium alloys which can chemically react with freons at high temperatures in the presence of water vapor. As concerns the corrosion resistance of bronze, brass, tin and lead in freons--there are very few data, and even these are contradictory [6, 7].

We encountered no papers dealing with the study of the corrosion resistance of metals in freons at high temperatures and pressures. These questions are of considerable scientific and practical interest.

We investigated the influence of one of the most common freons--freon-11 (boiling point 23.7C) on the corrosion of a wide range of metals and alloys in an unstressed state (aluminum, brass, copper, carbon and stainless steels and titanium alloys). The corrosion resistance of metals in freon was evaluated by the loss of weight relative to the original unit area of the sample.

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[1]Numbers in the margin indicate pagination in the foreign text.

The investigations were conducted at a temperature of 300°C and pressure of 60 atm. The investigation method is described briefly as follows: samples of the metals in the shape of round disks 20 mm in diameter with a thickness of 3 mm and a well polished surface, were washed to remove grease, then dried in desiccators and weighed to an accuracy of 0.0001 g. Thus prepared, the samples were placed on a support in a steel container which, with the aid of fluoroplastic or copper gaskets, were tightly closed with covers. To check the pressure, the containers were connected to manometers. The pressure inside the container was determined by the choice of the volume /179 of freon at room temperature. The filled containers were then put in an oven and maintained for a given time at a temperature of 300°C. After that, the corrosion products were removed from the samples, which were then washed, dried and weighed.

Our investigations (see table) showed that under the established conditions, practically all the above-mentioned metals and alloys react with freon. During the time assigned for the test, the most resistant to corrosion proved to be Kh17N2 steel. Nickel-free 4Kh13 steel is somewhat less resistant than Kh17N2 steel. Carbon steels, regardless of their carbon content (0.2-0.8%), also proved to be quite resistant, differing only little from stainless steels, while in acids or neutral electrolytes their corrosion resistance is many times lower than that of stainless steels.

Thorough investigation of the surface of the samples after testing showed that it remains practically unchanged in the case of Kh17N2 steel, while the surface of carbon steel becomes dull.

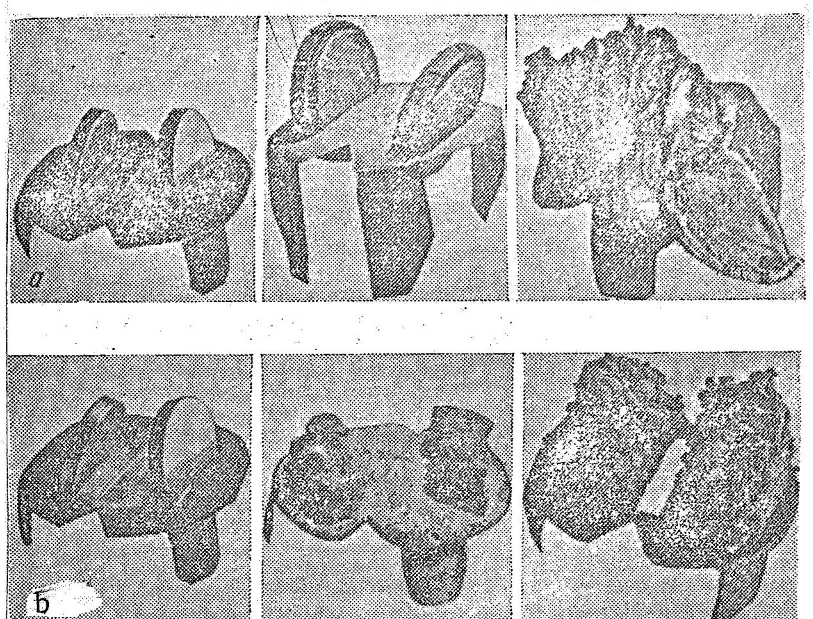

Fig. 1. Type of Deterioration of Copper (a) and Brass (b) after 7 and 50 Hours (samples prior to the test are shown at left).

Copper and brass were /180 found to be exceptionally low-resistant to corrosion in freon-11. Their resistance was 4-5 times lower than that of carbon steels. During the test, nearly the entire mass of brass was corroded. The picture shows copper and brass deteriorating.

Brass is characterized by flaky deterioration. The deterioration products of brass are very unstable--when kept in the air they decompose quite rapidly, accompanied by a weight increase, and grow dendriform copper crystals on the their surface while crystallization of copper from the deterioration products was not observed in the air. The VTZ-1 titanium alloy was found to be quite nonresistant in freon. Its resistance is one order lower than that of ordinary carbon steels. VD-17 aluminum alloy practically does not react with freon if the contact is of a short duration (up to 7 hours). By increasing time of contact, the losses of the metal in the alloy increase rapidly.

| Material | Heat Treatment | Loss of Weight (ml/cm$^2$)* | |
|---|---|---|---|
| | | After 7 hr. | After 50 hr. |
| Steel 20 | As delivered | 0.20 | 2.00 |
| Steel 45 | Annealed 850°C | 0.48 | 3.00 |
| U8 Steel | Annealed 800°C | 0.30 | 2.80 |
| 4Kh13 Steel | As delivered | 0.12 | 1.40 |
| Kh17N2 Steel | Tempered 1000°C<br>Annealed 680°C | 0.04 | 0.33 |
| VTZ-1 Alloy | As delivered<br>Annealed 500°C | 1.20 | 30.70 |
| Copper | As delivered | 312.10 | 856.20 |
| Brass | As delivered | 219.90 | 877.00 |
| VD-17 Alloy | As delivered | 0.00 | 11.70 |

*Translator's Note: probably mg/cm$^2$

REFERENCES


1. Rozenfel'd, L. M. and A. G. Tkachev, *Kholodil'nyye Mashiny i Apparaty*, [Refrigeration Machinery and Apparatus], Gostorgizdat Press, Moscow, 1960.
2. Petrov, A. A., Kh. V. Bal'yan and A. T. Troshchenko, *Organicheskaya Khimiya*, [Organic Chemistry], Vysshaya Shkola Press, Moscow, 1965.
3. Ioffe, I. S., *Organicheskaya Khimiya*, [Organic Chemistry], Goskhimizdat. Press, Leningrad, 1956.
4. Badyl'kes, I. S., *Kholodil'naya Tekhnika*, Vol. 9, No. 3, 1948.
5. Malash, and Gudlitskiy, *Khimiya Organicheskikh Soyedineniy Ftora*, [The Chemistry of Organic Compounds of Fluorine], Goskhimizdat Press, Moscow, 1961.
6. Eawrence, W. B., Refrig. Eng., Vol. 24, p. 286, 1932.
7. Midgley, T. I. and A. L. Honne, Ind. Chem., Vol. 22, p. 542, 1930.


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